ONTARIO WATER RESOURCES COMMISSION

REPORT on WATER QUALITY in CATCHACOMA LAKE 1971

RECREATIONAL LAKES PROGRAM

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ONTARIO WATER RESOURCES COMMISSION

REPORT

ON WATER QUALITY

IN

CATCHACOMA LAKE

1972

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SUMMARY

A study to evaluate the status of water quality in Catchacoma Lake was carried out during the summer of 1971.

Catchacoma Lake lies in the Canadian Shield in the County of Peterborough. The area is characterized by rolling hills, good local drainage, granitic bedrock and shallow overburden. Generally, the soil cover is less than the five feet required by the Department of the Environment for the installation of septic tank systems.

Thermal stratification was observed in Catchacoma Lake during the three sampling surveys. Oxygen concentrations in the bottom waters decreased slightly between the surveys. Free carbon dioxide concentrations were higher in the bottom waters than in the surface waters.

Chlorophyll a values were extremely low reflecting the low productive capacity of the oligotrophic status of thelake.

The chemical water quality was characteristic of soft water Precambrian lakes unaffected by waste inputs. The use of detergents containing phosphates is not necessary in such soft water and should be avoided by area residents.

Catchacoma Lake, during all three surveys, had very good bacteriological water quality. A bacterial input was detected at Station 19 at the northeast end of the lake, but the geometric means did not exceed the OWRC recreational use criteria.

In order to maintain the existing high quality of the water, every effort should be made to ensure that direct flow or leachate from domestic waste disposal systems or other potential sources of pollution do not gain access to the lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Water Resources Commission, The Ontario Department of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottage and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed problems which have come into prominence in recent years are caused by plant nutrients being added to the lake. Excessive algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard.

There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths, such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Catchacoma Lake in the summer of 1971. Three surveys were conducted; a spring survey from June 10 to 14, a mid-summer survey from August 6 to 10 and a fall survey from September 16 to 20 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution control program in Ontario.

AREA DESCRIPTION

Geography and Topography

Catchacoma Lake is located in Cavendish Township, Peterborough County approximately 56 kilometers (35 miles) north of Peterborough and 0.4 kilometers (0.25 miles) east of Highway 507.

The lake lies in the Canadian Shield, 22 kilometers (15 miles) north of the Dummer Till Moraine and the Kawartha Lakes. The area is characterized by rolling hills, good local drainage, granitic bedrock and very little overburden with the exception of localized glacial deposits. The soil is of the Wendigo series which is a Podzol soil characterized by loamy sand covering granite bedrock. Generally the soil cover is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of septic tank systems.

The shoreline is generally steep with heavily treed and rolling areas directly behind. The forest consists primarily of maple, white birch, white pine, hemlock and red pine trees.

The lake is roughly rectangular and lies in a north-south direction with a length of 5 kilometers (3 miles) and an average width of 2 kilometers (1.2 miles). The water surface area is 690 hectares (1700 acres) and the shoreline length 21 kilometers (13 miles). The maximum depth of the lake is 44 meters (144 feet) and the mean depth is 20 meters (67 feet). Aquatic vegetation is sparse and generally confined to inlet areas.

Climate Range

The area has a mean temperature of $-9^{\circ}C$ ($15^{\circ}F$) in January and $19^{\circ}C$ ($67^{\circ}F$) in July. The mean annual precipitation is 86 centimeters (34 inches) including 208 centimeters (82 inches) of snow. The summer claimate is conducive to most recreational activities and the winter with the early and abundant snow provides for participation in most winter sports.

Water Movement

The Catchacoma Lake drainage basin, 93 square kilomters (36 square miles) in area, forms the headwaters of the Mississagua River which flows into the Bay of Quinte via the Trent River System. The Catchacoma Lake drainage basin is roughly rectangular with water rising in the north-east corner at an elevation of 381 meters (1,250 feet) above mean sea level (m.s.l.) and flowing by way of small lakes and streams to Catchacoma Lake at an elevation of 295 meters (966 feet) above mean sea level.

There are five tributaries, all with very low flows, entering Catchacoma Lake. Three of the five streams are unnamed and the remaining two are: Pencil Creek which drains Pencil and North Pencil lakes; and Bottle Creek which drains Sucker and Bottle lakes. Bottle Creek has a concrete control dam at its entrance to Catchacoma Lake. Catchacoma Lake flows into Mississagua Lake via the Mississagua River. Both lakes are at the same elevation which is controlled by a dam at the outlet of Mississagua Lake. The dam is regulated by the Federal Ministry of Transport. Reportedly lake level fluctuations of up to 2 meters (6.5 feet) have been known to occur.

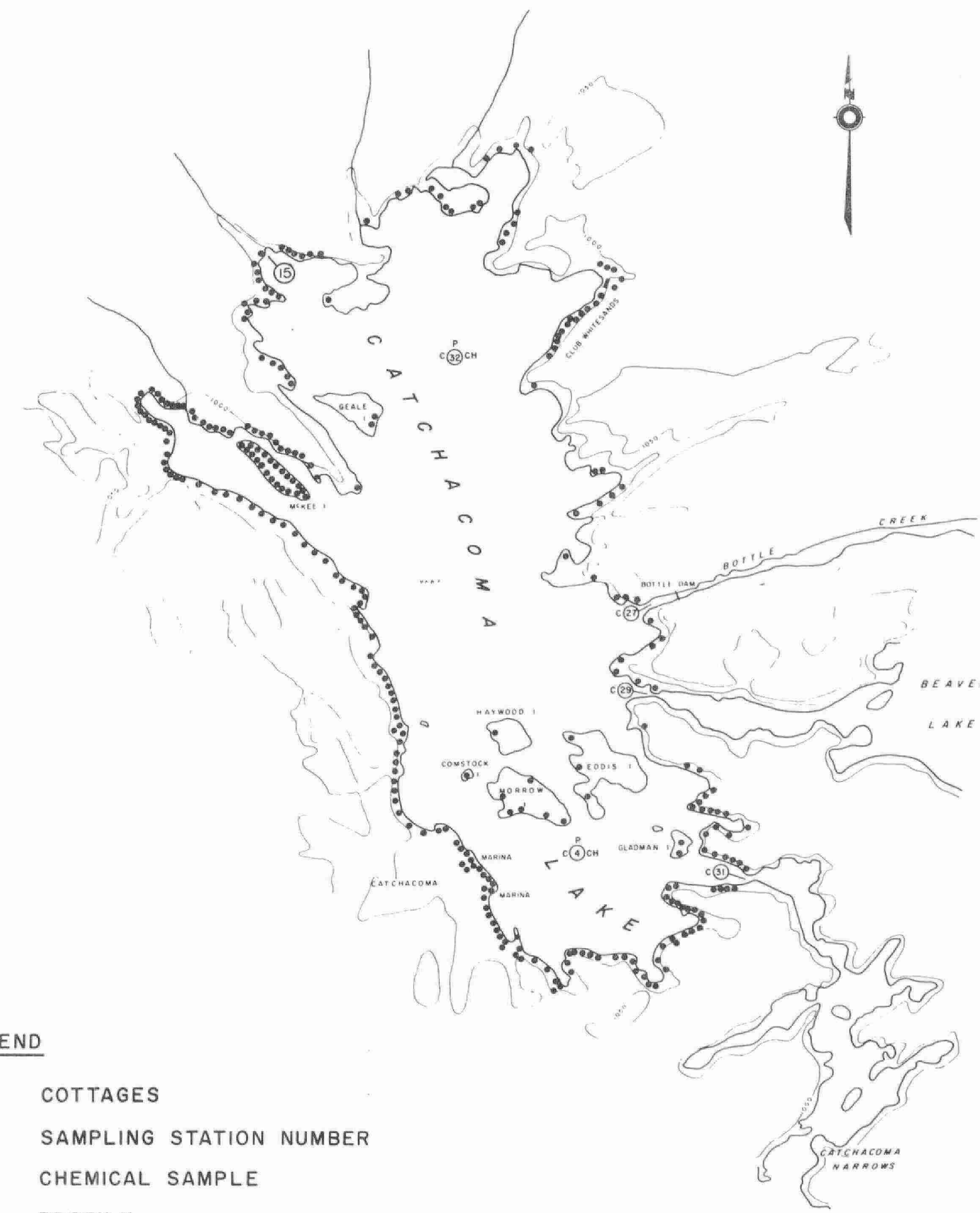
Shoreline Development

Road access via Highway 507 has led to the development of the western and northern shores of Catchacoma Lake. These two shorelines have 70% of the 290 cottages on the lake. Approximately one-half of the cottages are accessible by boat only and are served by the two marinas. The Department of Lands and Forests controls 21% of the land around the lake while the remaining 79% is patent. Cottage spacing is generally good although some areas in the northwest appear to be crowded. The appended map shows the approximate locations of the cottages (Figure 1).

Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According

FIGURE 1



LEGEND

- ● COTTAGES
- ④ SAMPLING STATION NUMBER
- C CHEMICAL SAMPLE
- P PROFILE
- CH CHLOROPHYLL SAMPLE
- 1000 CONTOUR LINE

STATUTE MILES

1/2 3/4 0 1 MILE

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to information available from the Department of Lands and Forests the most common fish are lake trout, smallmouth and largemouth bass and white suckers. Stocking of Catchacoma Lake with lake trout has been carried on with some regularity since 1956.

There are no direct discharges of wastes to Catchacoma Lake from communal or municipal sewage treatment facilities. There does not appear to be any pollution from the operation of existing municipal solid waste disposal sites.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Physical, chemical and biological water quality surveys were conducted from June 10 to 14; from August 6 to 10 and from September 16 to 20 on Catchacoma Lake. Four near-shore stations (15, 27, 29 and 31) and two mid-lake stations (4 and 32) were selected for physical, chemical and biological sampling (Figure 1).

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each station, utilizing a composite sampler lowered through the euphotic zone (2x Secchi disc) and immediately preserved with 10-15 drops of 2% $MgCO_3$.

Once per survey at mid-lake stations and at least once per season at near-shore stations a 32 ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

On August 10, 1971 at both mid-lake stations, a sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above the bottom.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 mμ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five day intensive bacteriological surveys were completed on Catchacoma Lake during June, August and September. Thirty-one stations in June and August and 23 stations in September were sampled each day one meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. An additional sample was collected at station 4 one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber syringes (Figure 5). All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoide) was used for fecal coliform determinations. The total coliforms (TC) fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden green metallic sheen within 24 hours of incubation"

using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5^{o}C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms indicates that at lease a portion of the coliforms in the sample are of fecal origin.

A calculation of the ratio FC/FS using geometric mean levels can be helpful in determining the origin of the bacterial contamination. If the FC/FS ratio is 0.7 or less, the pollution is from direct animal discharge into the water or more likely storm water runoff. If the FC/FS ratio is 4.0 or greater, the pollution source is domestic sewage. Although this guideline is not infallible, it has been proven by several observations (Geldreich, 1968).

All the bacteriological data collected in these surveys has been summarized by statistical methods to form a concise outline of the bacterial concentrations.

Bacteriological Statistical Methods

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antiloqarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-cre; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both of these assumptions were checked on Catchacoma Lake, with the result that the TC mean for Station 13 during the June survey was removed to accommodate the Bartlett's test of Homogeneity.

Then the analysis of variance (F-test; Sokal, 1969) was calculated on all the stations for TC, FC and FS except for the TC for Station 6. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys to each other.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

During the June survey, a well defined thermocline characterized by a temperature change of approximately 7°C was apparent between 4 and 7m (Figure 2a and 3a). There was a slight oxygen reduction through the metaliminion with no severe oxygen reduction being evident in the bottom waters.

An increase in the temperature of the epilimnion was evident between the June and August surveys at both stations. Supersaturated dissolved oxygen concentrations were present in the epilimnion and upper metaliminion.

In September, the thermocline was somewhat deeper than during the preceding surveys, being located between 7 and 11m depths at Station 32 and between 6 and 11m at Station 4 (Figures 2b and 3b). This downward shift was in keeping with the expected seasonal changes characteristic of small inland lakes. A severe hypolimnetic decrease was not observed, but deep water saturations were slightly lower than those detected earlier in the year. This hypolimnetic decrease was probably related to the decomposition of the current years' production of algae by bacterial oxidation, biolological respiration and chemical oxidation.

Hardness, Chloride, Conductivity and Iron

The hardness, chloride, conductivity and iron data are given in Table 1.

The values are normal for soft-water Precambrian lakes and are consistent with each other confirming that no unusual mineral characteristics were present. Detergents containing phosphorus are unnecessary in such soft water and their use should be avoided by area residents.

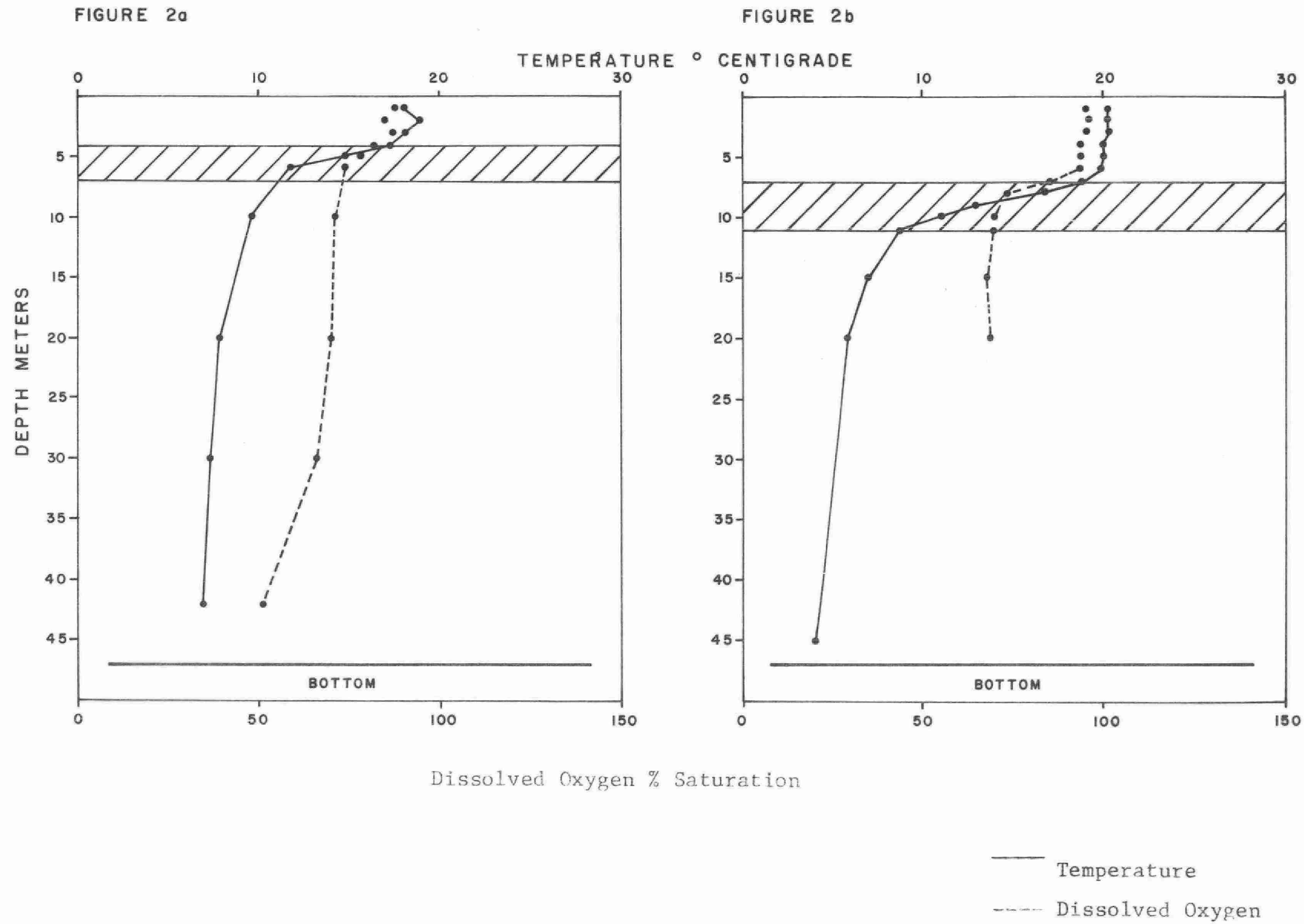


FIGURE 2: Temperature and dissolved oxygen profiles in Catchacoma Lake, Station 32 for (a) June 12, 1971 and (b) September 19, 1971. The shaded areas approximate the position of the thermocline.

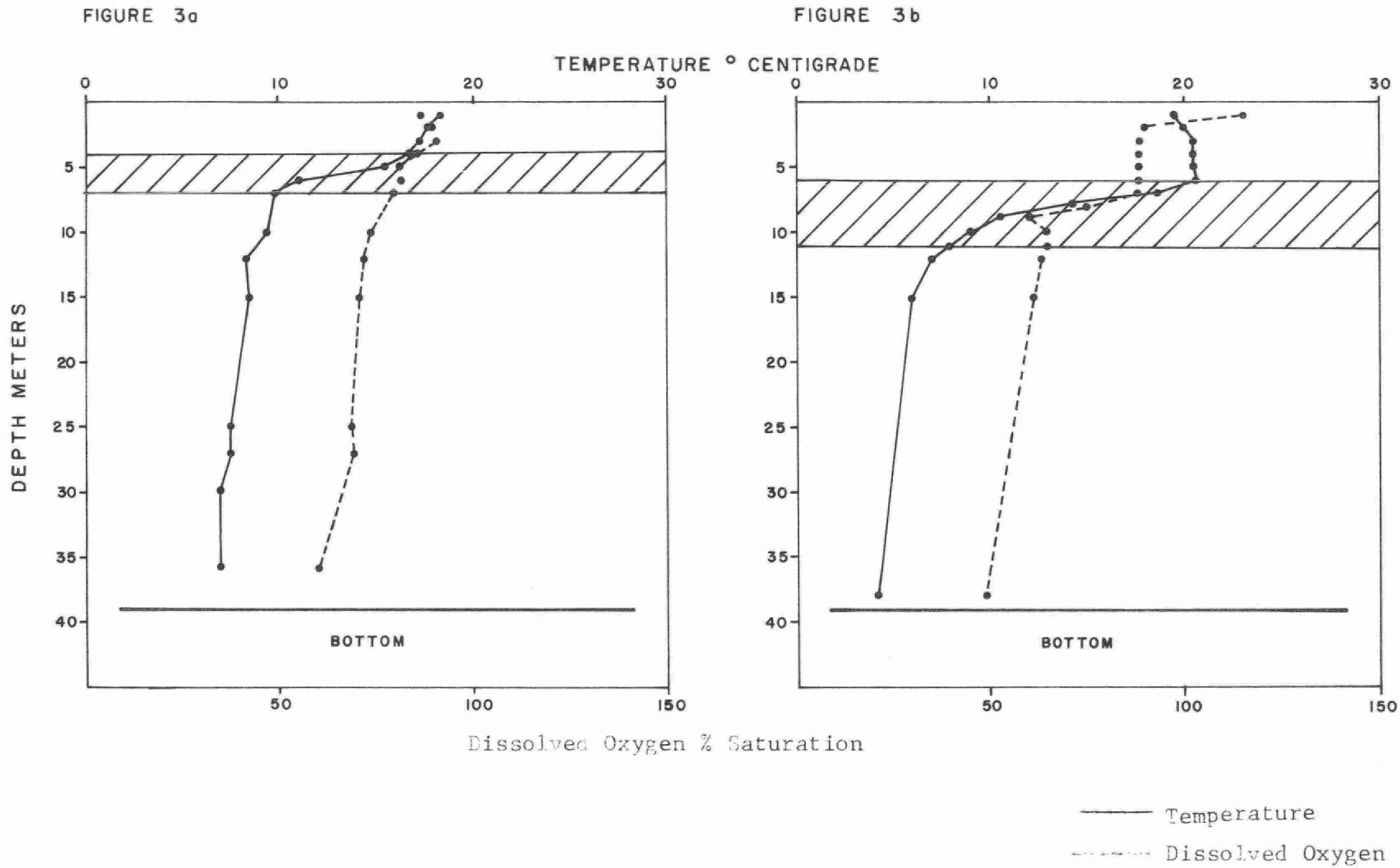


FIGURE 3: Temperature and dissolved oxygen profiles in Catchacoma Lake, Station 4 for (a) June 11, 1971, and (b) September 18, 1971. The shaded areas approximate the position of the thermocline.

Kjeldahl Nitrogen and Total Phosphorus

The nitrogen and phosphorus concentrations were quite low (Table 1) and would not be expected to cause any algal problems. The average weight ratio of nitrogen to phosphorus was 33 which is characteristic of natural water unaffected by waste inputs (Edmondson 1970).

pH, Total Alkalinity and Free Carbon Dioxide

In Catchacoma Lake, the pH and total alkalinity were generally higher in the surface waters than in the deeper strata. For example, at Station 32 on June 13, the pH values at 1 and 46m were 6.3 and 5.9 respectively while the corresponding total alkalinity concentrations were 12.7 and 11.6 mg/l. Free carbon dioxide concentrations were usually higher in the bottom waters than in the warmer surface waters. On June 14, the free carbon dioxide at 1 and 35m (Station 4) were 4.5 and 14.2 mg/l respectively. The increased carbon dioxide and reduced pH values in the hypolimnion are related to conditions of organic decomposition.

Chlorophyll a

The chlorophyll a concentrations and Secchi disc values from Stations 4 and 32 are presented in Table 1. Chlorophyll a concentrations were extremely low ranging from 0.4 to 0.9 ug/l 0.5 to 1.3 ug/l and 0.4 to 0.8 ug/l for the June, August and September surveys, respectively.

Water clarity, which is one of the more important parameters used in defining water quality, may be measured using a Secchi disc. Figure 4 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and clarifies the 'trophic status' of Catchacoma Lake in relation to numerous other well known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationship). With respect to Figure 4, Catchacoma Lake is positioned between values observed for the oligotrophic lakes Superios and Huron and the more mesotrophic Lake Ontario and Eastern Basin of Lake Erie. The lake was well removed from the Bay of Quinte, Gravenhurst Bay and Riley Lake, three extremely enriched bodies of water.

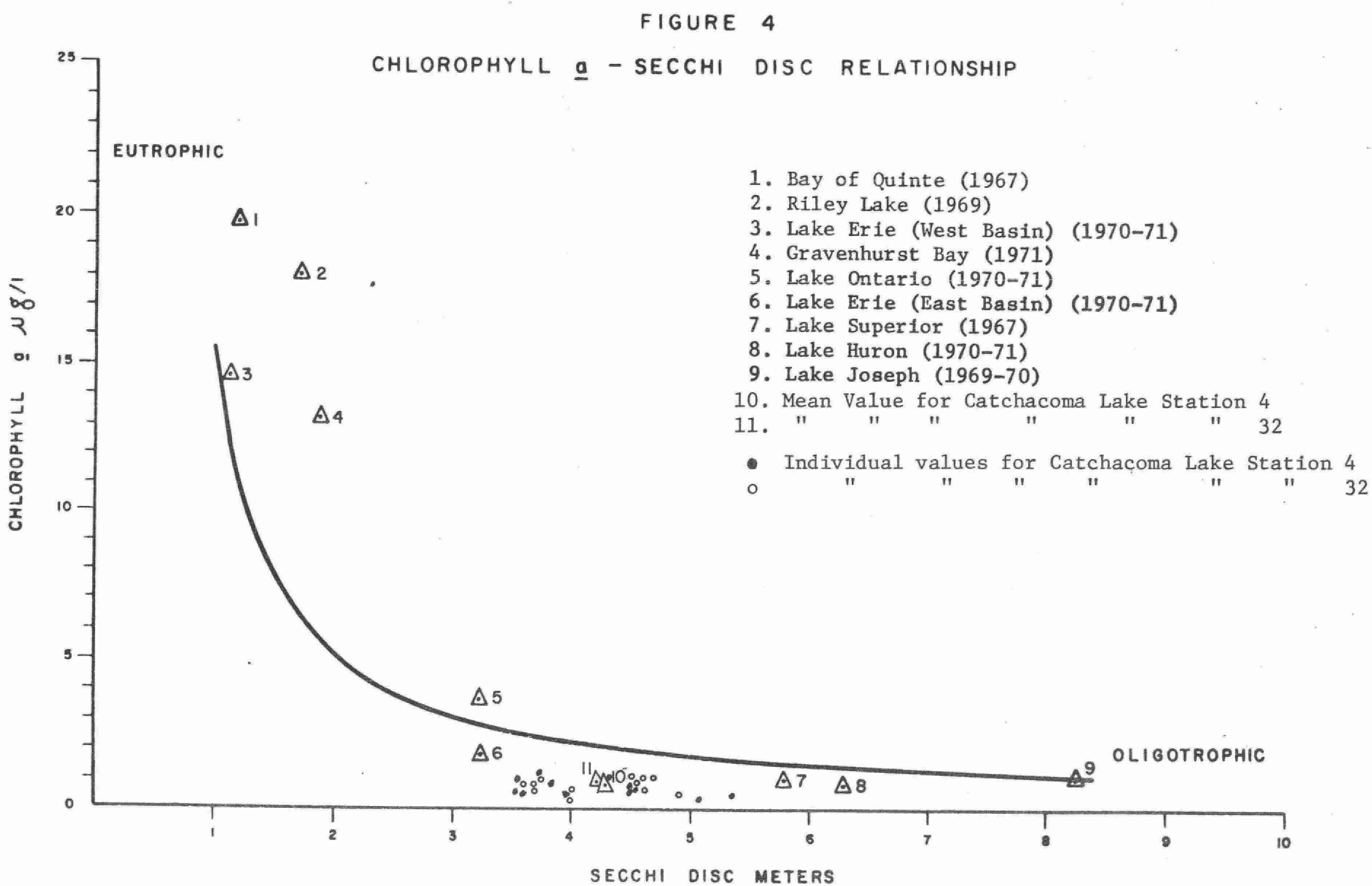


FIGURE 4: The relationship between chlorophyl a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual chlorophyl a - Secchi disc values for Stations 4 and 32 on Catchacoma Lake. The Great Lakes values were added for comparative purposes.

Bacteriology

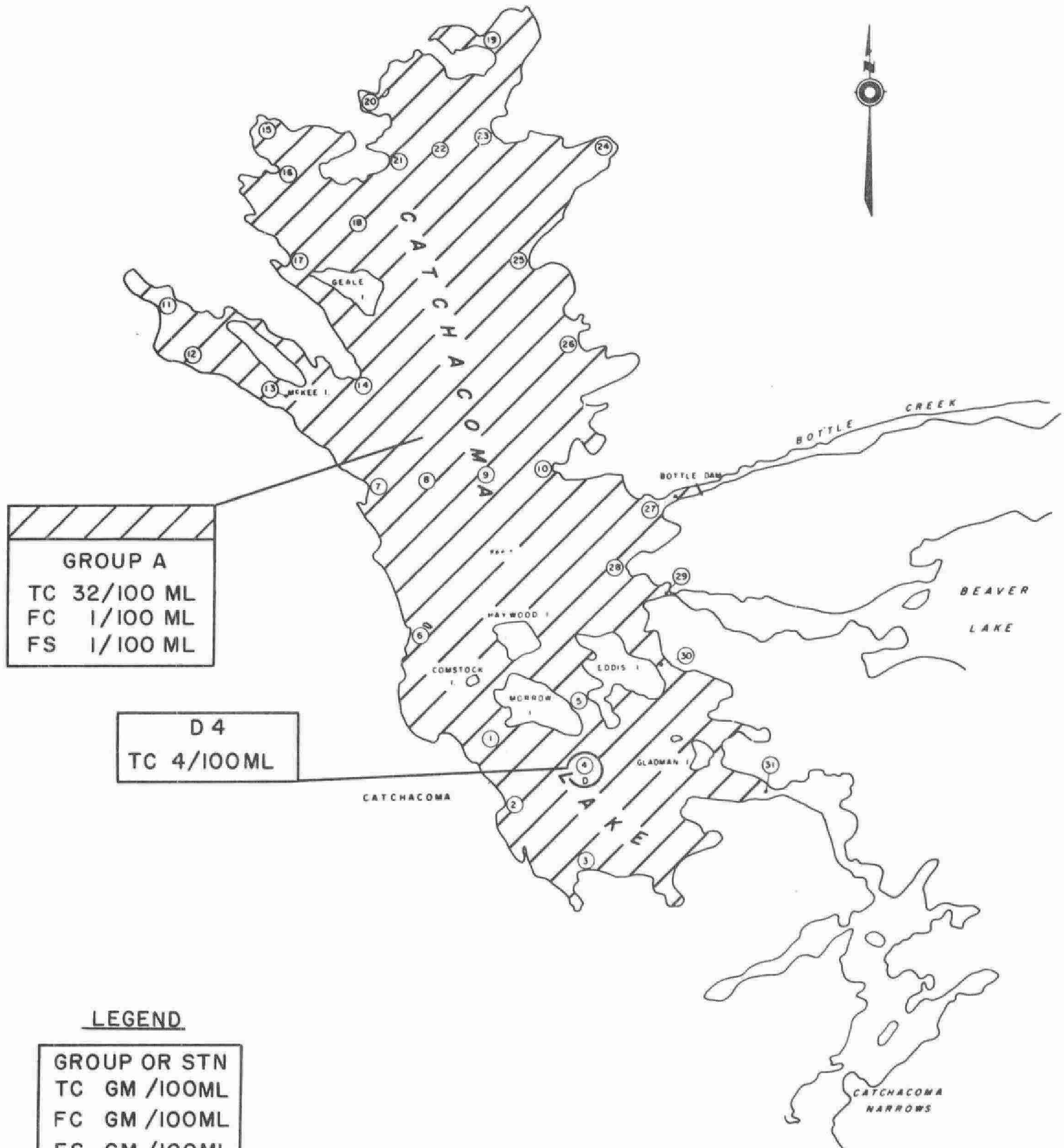
During the three surveys, bacterial counts for Catchacoma Lake were well within the OWRC criteria for total body contact recreational use (OWRC, 1970).

In June, the lake was homogeneous having very low bacterial levels with geometric means (GM) of 32 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml (Group A, Figure 5) with the exception of the depth Station 4D which had a lower TC level of 4/100 ml. Rainfall, recorded at the climatological station at Haliburton (0.83 inch on June 7 and trace amounts on June 12), induced runoff which probably caused increased TC and background levels at the majority of stations on June 13. Station 6, with a GM of 63 TC/100 ml was adjacent to a lightly cottaged area and displayed the highest variance due to runoff, fluctuating from 2,300 TC per 100 ml on June 13 to 4 TC/100 ml on June 14.

Catchacoma Lake during the August survey was homogeneous with overall geometric mean of 8 TC/100 ml, 1 FC/100 ml and 3 FS/100 ml (Group A, Figure 6) with the exception of Stations 2, 13, 19, 23 and 27. Station 2, near the southwest shore, had a slight but statistically higher FC mean of 2/100 ml. Station 13 was removed to accommodate the Bartlett's test of homogeneity because of its high TC variance, but its mean was similar to that of Group A. Station 19 near a small stream-fed inlet at the north-east end of the lake, had higher bacterial levels of 20 TC/100 ml and 20 FC/100 ml. The ratio of FC to FS geometric means at this station indicated a source of domestic pollution (Geldreich 1968). Station 23 opposite an uninhabited area of the lake had a significantly lower TC level of 4/100 ml. Station 27 at the mouth of Bottle Creek had significantly higher TC and FC levels at 25/100 ml and 2/100 ml respectively

FIGURE 5

JUNE SURVEY



LEGEND

GROUP OR STN
TC GM /100ML
FC GM /100ML
FS GM /100ML

(4) — BACTERIOLOGICAL STATION

D — DEPTH STATION

STATUTE MILES

1/2 3/4 0 1 MILE

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CATCHACOMA LAKE

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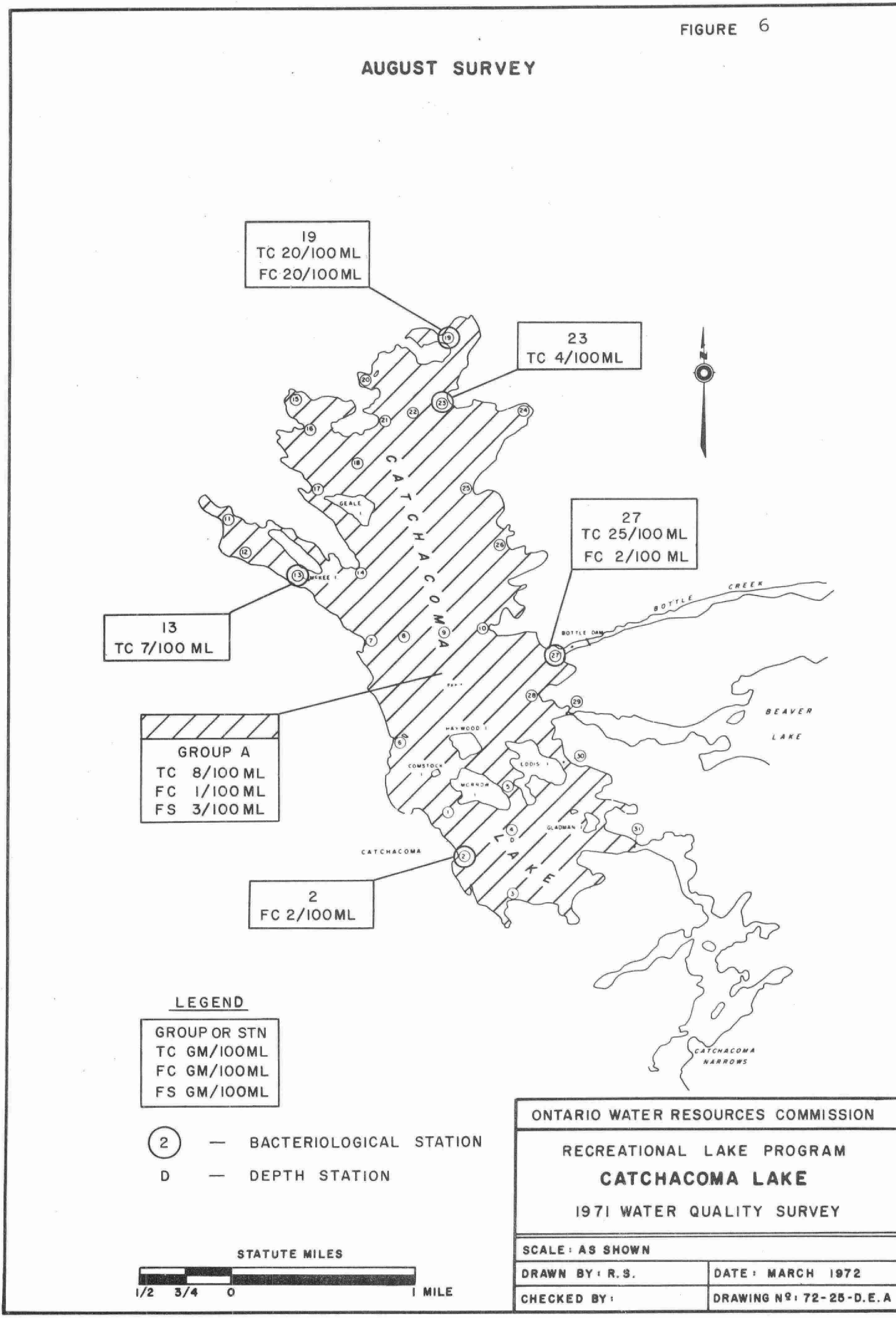
FIGURE 6
AUGUST SURVEY
19
TC 20/100 ML
FC 20/100 ML
23
TC 4/100 ML
27
TC 25/100 ML
FC 2/100 ML
13
TC 7/100 ML
GROUP A
TC 8/100 ML
FC 1/100 ML
FS 3/100 ML
2
FC 2/100 ML
CATCHACOMA LAKE
BOTTLE CREEK
BOTTLE DAM
BEAVER LAKE
CATCHACOMA
CATCHACOMA NARROWS
GEALE I.
HAYWOOD I.
COMSTOCK I.
LOOIS I.
GLADMAN I.
LEGEND
GROUP OR STN
TC GM/100ML
FC GM/100ML
FS GM/100ML
2 — BACTERIOLOGICAL STATION
D — DEPTH STATION
STATUTE MILES
1/2 3/4 0 1 MILE
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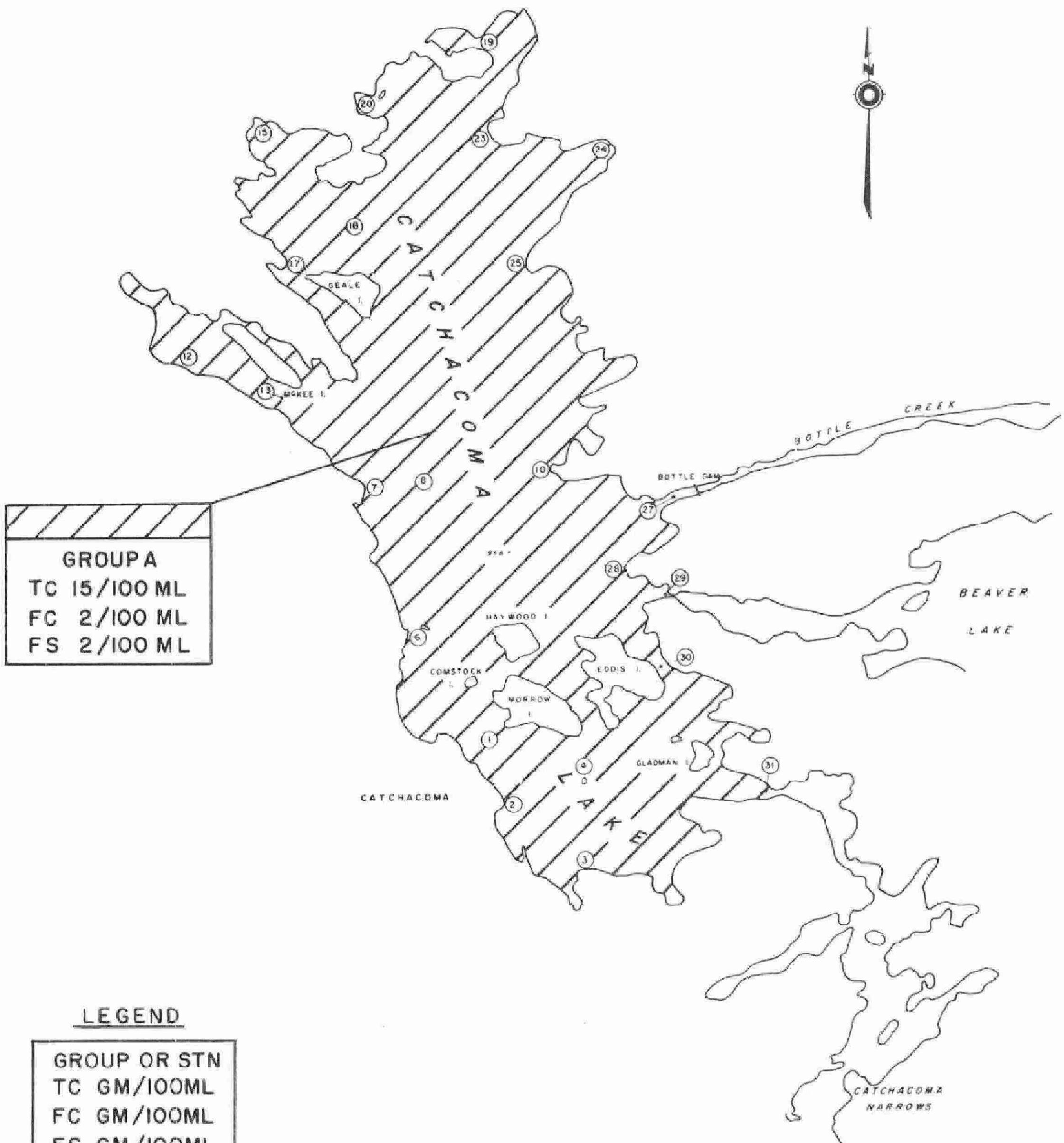
Throughout the September survey (Figure 7) bacterial levels were uniformly low with means of 15 TC/100 ml, 2 FC/100 ml and 2 FS/100 ml. Precipitation on September 15, 17 and 19 was responsible for increasing background and FS counts at some shoreline stations to unacceptable levels on the days subsequent to this rain.

Generally, the June and September surveys had higher TC levels than in August. The higher TC levels in June and September were probably due to rainfall during the surveys. FC and FS means throughout all three surveys were uniformly low.

Although the water quality is very good for recreational use, surface water is not considered potable without prior treatment including disinfection.

FIGURE 7

SEPTEMBER SURVEY



LEGEND

GROUP OR STN
TC GM/100ML
FC GM/100ML
FS GM/100ML

4 — BACTERIOLOGICAL STATION

D — DEPTH STATION

STATUTE MILES

1/2 3/4 0 1 MILE

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TABLE 1

Iron, Hardness (Hard), Total Phosphorus (P), Kjeldahl nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Catchacoma Lake 1971. The results are expressed as mg/l except conductivity which is μmho/cm^3.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
4	11m comp*	11/6	0.20	24	0.010	0.29	2	-
	8.6m comp	10/8	0.20	24	0.025	0.24	1	58
	26m	10/8	0.15	-	0.012	0.24	-	-
	7.2m comp	20/9	0.05	24	0.004	0.25	2	56
15	1m	14/6	0.10	26	0.010	-	4	-
	1m	10/8	0.10	-	0.012	0.23	1	58
27	1m	10/8	0.15	22	0.010	0.27	1	52
	1m	20/9	0.10	24	0.008	0.30	2	56
29	1m	10/8	0.10	24	0.010	-	1	55
	1m	20/9	0.05	24	0.004	0.27	2	56
31	1m	10/8	0.10	26	0.012	-	1	57
	1m	20/9	0.05	24	0.010	0.29	2	56
32	11m comp	11/6	0.10	24	0.002	0.07	2	-
	7.6m comp	10/8	0.05	24	0.006	0.21	1	57
	41m	10/8	0.40	-	0.016	0.19	-	-
	8m comp	20/9	0.05	24	0.006	0.29	1	56

* comp = composite sample over the depth specified

TABLE 2

Chlorophyll *a* and Secchi disc values for Catchacoma Lake, Stations 4 and 32, during 1971.

	STATION 4		STATION 32	
	Chlor. *a*	S.D.	Chlor. *a*	S.D.
June 11	0.5 μg/l	5.5m	0.7 μg/l	4.5m
June 12	0.6	4.6	0.6	4.0
June 13	0.6	4.0	0.9	4.5
June 14	0.4	5.1	0.6	4.9
Aug. 6	1.1	3.6	0.9	3.7
Aug. 7	1.1	3.9	0.5	4.5
Aug. 8	0.6	4.5	1.1	4.5
Aug. 9	1.3	3.7	1.1	4.7
Aug. 10	1.1	4.3	1.1	3.8
Sept. 18	0.7	4.5	0.6	3.6
Sept. 19	0.5	3.5	0.8	3.5
Sept. 20	0.4	3.6	0.4	4.0
MEAN	0.74	4.23	0.78	4.18

Chlor. *a* = Chlorophyll *a*

S.D. = Secchi Disc

μg/l = Micrograms/Liter

m = Meter

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F	-	the calculated analysis of variance statistic on F ratio.
df	-	degrees of freedom of the F ratio for "between group" and "within group" variation.
F(5%)	-	the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
log GM	-	the logarithm (base 10) of the geometric mean.
S.E.	-	the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N	-	the number of values in the mean.
GM	-	the geometric mean of the bacterial level.
t	-	the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

TABLE 3

Summary of the Analysis of Variance Grouping of Stations

PARAMETER: Total Coliform (TC)/100 ml.

Survey	June 10 - 14, 1971	August 6 - 10, 1971	September 16 - 20, 1971
Group	All Stations	All Stations	All Stations
F	1.556	0.901	1.637
df	31 , 125	31 , 121	23 , 95
F(0.5)	1.552	1.555	1.649
	SD	NSD	NSD
Group	A All stations except 4D	A All stations except 13, 19, 23 and 27	A All stations
F	1.239	0.823	1.637
df	30 , 122	27 , 106	23 , 95
F(0.5)	1.561	1.550	1.649
	NSD	NSD	NSD
Log GM	1.509	0.903	1.164
SE	0.044	0.041	0.022
N	153	134	119
GM	32	8	15

TABLE 4 - Summary of the Analysis of Variance Grouping of Stations
Parameter: Fecal Coliform (FC)/100 ml

Survey	June 10 - 14, 1971	August 6 - 10, 1971	September 16 - 20, 1971
Group	All Stations	All Stations	All Stations
F	1.541	12.955	1.046
df	31 , 126	31 , 125	23 , 95
F(0.5)	1.551	1.552	1.649
	NSD	SD	NSD
Group	A All stations	A All stations except 2, 19, 27	A All stations
F	1.541	0.902	1.046
df	31 , 126	28 , 113	23 , 95
F(0.5)	1.551	1.583	1.649
	NSD	NSD	NSD
Log GM	0.088	0.012	0.251
SE	0.016	0.007	0.034
N	158	142	119
GM	1	1	2

TABLE 5 - Summary of the Analysis of Variance Grouping of Stations
Parameter: Fecal Streptococcus (FS)/100 ml.

Survey	June 10 - 14, 1971	August 6 - 10, 1971	September 16- 20, 1971
Group	All Stations	All Stations	All Stations
F	0.899	1.368	0.965
df	31 , 118	31 , 127	23 , 95
F(0.5)	1.557	1.551	1.649
	NSD	NSD	NSD
Group	A	A	A
	All stations	All stations	All stations
F	0.899	1.368	0.965
df	31 , 118	31 , 127	23 , 95
F(0.5)	1.557	1.551	1.649
	NSD	NSD	NSD
Log GM	0.089	0.412	0.257
SE	0.016	0.038	0.036
N	150	159	119
GM	1	3	2

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL a	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellulr plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION : The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.

FECAL COLIFORMS (FC) : Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.

FECAL STREPTOCOCCUS (FS) : Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.

HARDNESS : Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.

HYPOLIMNION : The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1

KJELDAHL NITROGEN : Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).

MESTROPHIC : Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).

METALIMNION : See thermocline.

OLIGOTROPHIC : Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.

pH : Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.

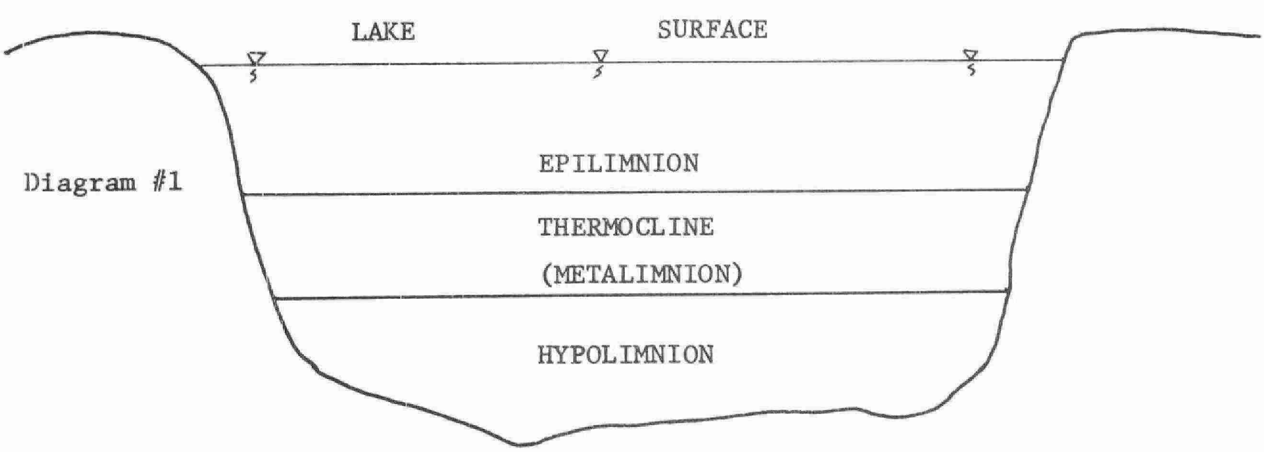
PHOSPHORUS (TOTAL) : Sum of all forms of phosphorus present in the sample.

SECCHI DISC :A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion) :The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding $1^{o}C$ increase per meter.

Diagram #1



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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> Microbiological Criteria
> Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, throat, nose and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least 10 samples per month, including samples collected during weekend periods.

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